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THE EFFECTS OF HUNTING ON GAMBEL QUAIL POPULATIONS[1]

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"Of the many species of game found in Arizona the Gambel quail ranks first in importance" (Gorsuch, 1934). With the 15-bird daily limit and 60-day season then in vogue it is little wonder that Gorsuch ranked this bird at the top. It was not many years after the completion of his study, however, that quail hunting in Arizona virtually came to a stop.

Following one of the periodic dips in population characteristic of desert quail, the hunting season was either closed entirely from 1944 to 1951 or limited to short, two- to three-day hunts on restricted areas. Within ten years the status of this game bird changed from that of first to somewhere near last in importance.

It is difficult now to determine with certainty whether the restrictions on quail hunting were due to the belief that hunting had brought

[1]A contribution from Pittman-Robertson Project W-78-R (Arizona).

about the population crash or to concern over the possibility that hunting would aggravate a situation created by other forces. Regardless of the reason, once the practice began of treating this species as though it were on the verge of extinction, there was seemingly some reluctance to again permit a reasonable amount of hunting.

The results of other quail studies, including work on the closely related California valley quail showing that hunting was generally not a factor limiting quail numbers, were evidently not thought to be applicable to conditions in Arizona.

In 1951 a study was instituted with the specific purpose of determining the influence of hunting on desert quail. Was hunting really a limiting factor? And if an affirmative answer was indicated, at what point did it become so? Did quail population density have any bearing on the answer? What percentage of a quail population would hunters take under conditions existing in this state? Would the percentage of take vary, and, if so, how much of the variation was dependent on hunting pressure and quail density? How would a population protected from the gun respond compared to one hunted?

An earlier paper (Swank and Gallizioli, 1954) reported on the first three years of the study. The results of the subsequent four years work corroborate the early findings and shed light on some of the questions posed above.

While most of the work has been confined to the original area near Oracle Junction, a second area was selected for limited study in 1956. Named the Pinnacle Peak area after a prominent landmark, it is located 25 miles north of Phoenix. Like the Oracle Junction area near Tucson, it receives heavier than average hunting pressure due to its proximity to metropolitan Phoenix. It was established largely to provide kill and hunt statistics comparable to those from the Oracle Junction area.

The Pinnacle Peak area lies in a desert shrub type. Dominant plants are saguaro cactus (*Carnegiea gigantea*) and paloverde (*Cercidium floridum*) with a bursage (*Franseria dumosa*) understory. Shrubby hackberry (*C. pallida*) is abundant. Chollas and prickly-pear are found in varying amounts throughout. Herbaceous cover is scarce with only remnant perennial grasses persisting, mostly tobosa (*Hilaria mutica*). The elevation here is approximately 2,000 feet and annual precipitation at nearby Bartlett Dam averages 12.04 inches.

The original study area at Oracle Junction lies some 20 miles north of Tucson. It is in reality two "areas," one open to quail hunting in season, and an adjacent control area which has been closed to quail hunting since the inception of this study. Elevation is approximately

TABLE 1. SUMMARY OF HUNT STATISTICS FROM ORACLE JUNCTION CHECKING STATION, 1951-1957

	1951[1]	1952[1]	1953		1954		1955		1956		1957	
	All Hunters	All Hunters	Study Area Only	All Hunters	Study Area Only	All Hunters	Study Area Only	All Hunters	Study Area Only	All Hunters	Study Area Only	All Hunters
No. hunters	1594	1090	510	1471	272	1068	226	1275	61	835	61	886
Total No. quail bagged	3234	4304	1012	4607	765	6474	433	3206	25	1388	51	1761
Scaled quail	72	125	82	190	42	184	62	159	2	19	3	16
Average bag	2.03	3.92	2.0	3.27	2.77	6.31	1.93	2.51	0.31	1.66	0.84	1.98
Bag per 100 gun hours	43	99	63	85	84	89	60	63	13	44	32	63
Per cent hunters with limit bags	20	20	6	17	12	17	6	10	0	6	0	9
Per cent juveniles among Gambel quail bagged	44	70	44	43	56	53	30	28	5	20	77	74
Per cent juveniles among scaled quail bagged	50	70	61	63	64	62	45	53	0	35	67	81
No. quail lost per 100 bagged	31	23	29	27	26	29	20	27	28	20	29	26

[1]Study area hunt data were not kept separate in 1951 and 1952.

3,500 feet, and annual rainfall at nearby Oracle averages 18.65 inches. Both hunt and control areas fall in what may be classed a grassland-desert shrub type. Dominant plants consist of a mixture of scattered shrubby mesquites (*Prosopis juliflora*) and hackberry (*Celtis pallida*), several species of cholla (*Opuntia* sp.), soaptree yucca (*Yucca elata*), and barrel cactus (*Ferocactus Wislizeni*) with an understory of burroweed (*Applopappus tenuisectus*), prickly-pear (*Opuntia Engelmannii*) and perennial grasses. Along the washes which intersect the area a more arboreseent type of vegetation occurs characterized by larger mesquites, a tree-size hackberry (*Celtis reticulata*), velvet ash (*Fraxinus velutina*), and catclaw (*Acacia Greggii*).

In addition to Gambel quail some scaled quail are found on a portion of this area. Being near the northern boundary of its range in Arizona the scaled quail has never been abundant here. Kill records (Table 1) show it has made up about ten per cent of the total bag. Presumably this is the ratio in which it exists in the total quail population of the area.

PROCEDURE

Early in the study the problem of determining with reasonable accuracy the population densities of the two areas at Oracle Junction became of paramount importance. Foot surveys following compass lines (1951) and over pre-established and marked transects (1952) proved to be subject to great variation when analyzed statistically (Swank and Gallizioli, *op. cit.*).

Since 1953 population density has been calculated by means of the Lincoln Index on the hunt area. Quail were banded during two periods: in September and in November immediately prior to the December hunting season. Trapping in September was confined to a 446-acre segment of the 12-square-mile hunt area. Returns of September-trapped birds permitted a determination of the extent of natural mortality during the September-December period. Checking stations were operated at both study areas thoughout each quail sea-

TABLE 2. HUNT DATA FROM PINNACLE PEAK CHECKING STATION, 1956-1957

	1956	1957
Total hunters	906	1117
Total quail bagged	1485	2050
Man hours hunted	3747	4442
Number birds lost	401	600
Juvenile quail	87	1301
Adult quail	1202	814
Average bag per hunter day	1.63	1.80
Quail bagged per 100 gun hours	40	46
Number quail lost per 100 bagged	27	24
Per cent juveniles in hunters' bags	7	72
Per cent population removed by hunting (bag and cripples)	12	16

TABLE 3. COMPARISON OF FALL POPULATION DENSITY (QUAIL PER 100 ACRES) ON HUNT AND CONTROL AREAS, ORACLE JUNCTION STUDY AREA

Year	Hunt Area	Control Area
1952	97	
1953	71	45[1]
1954	65	63[1]
1955	40	40[1]
1956	9	
1957	13	

[1]Personal communication from Dr. Lyle Sowls dated January 28, 1958.

son to secure an accurate check on banded birds taken and to gather information on quail hunting not only on the study area but in the surrounding territory as well. A summary of hunt data from both checking stations is shown in Tables 1 and 2.

Since the control area at Oracle Junction was closed to hunting it was not possible to determine population density as it was on the hunt area where checking of hunters permitted the use of the Lincoln Index. Other techniques were tried including a formula by Lagler (1950) and a modified Lincoln Index using color-banded birds introduced into the population. Neither proved satisfactory.

From 1951 through 1956 the Wildlife Research Unit at the University of Arizona under Dr. Lyle Sowls conducted intensive quail population studies on several areas near Tucson. One area known as Page Ranch forming part of the control area was studied in 1953, 1954, and 1955. Population density figures for the control area in Table 3 are those obtained by Dr. Sowls for the Page Ranch area.

FINDINGS

Following completion of the seventh year of study several major conclusions can be drawn that are of importance to management.

1. Hunting was not responsible for the population changes on the hunt area.

Density was about the same on the hunted and control areas in 1954 and 1955 (Table 3) but considerably lower on the control area in 1953. When the first significant drop in quail density occurred in 1955 it was equally severe on the control as on the hunted area, amounting to approximately 40 per cent of the 1955 population level. Since the Research Unit's study was terminated in 1955, no objective data for the control area are available for 1956 and 1957 when density on the hunt area reached its lowest level. It is known, however, that numbers were considerably lower than the 1955 level. A drive census by a wildlife class from the University of Arizona in the fall of 1957 flushed but one quail in 80 acres (Sowls, in conversation). From this and limited footwork on our part it seems reasonable to assume that

TABLE 4. GAMBEL QUAIL POPULATION CHANGES ON HUNTED AND UNHUNTED AREAS (MODIFIED FROM WRIGHT AND WEBB, 1957).

Year	Hunted Area		Unhunted Area	
	Population	Per cent change	Population	Per cent change
1953	2060		4193	
1954	2097	− 5	3631	−13
1955	1011	−50	2345	−38
1956	575	−43	1128	−50
Per cent reduction 1953-1956		−72		−73

the control area population dropped to a level probably as low as that of the hunt area.

On an independent study concerned with the value of rainwater catchments in Arizona, Wright and Webb (1957) found a 72 per cent reduction in Gambel quail numbers between 1953 and 1956 on a hunted area and a 73 per cent reduction during the same period on a second study area located on a refuge (Table 4). Obviously the population changes at Oracle Junction were not a local phenomenon since the areas studied by Wright and Webb were more than 100 miles north of Oracle Junction, at lower elevations, and in different vegetative types. Violent fluctuations in southwestern quail have been reported by other workers and are apparently the result of the extremes of wet and dry years. *Jackson (1947) and Lehmann (1953) found* both bobwhites and scaled quail in Texas subject to extreme changes in population density. In southern Nevada, Gullion (1954) reported equally violent changes in Gambel's quail populations.

2. *Under hunting conditions and regulations as they now exist in* Arizona, it is unlikely that more than 30 per cent of the prehunt population will be removed by hunters even in the most heavily hunted areas.

During the course of this study the heaviest kill occurred in 1953 when bag and crippling loss combined accounted for 24 per cent of the preseason population. As quail density decreased, so too did the kill until in 1956 and 1957 at Oracle Junction it dropped to an insignificant four to six per cent of the prehunt population (Table 5). The results

TABLE 5. POPULATION DENSITY (QUAIL PER 100 ACRES) AND KILL AT ORACLE JUNCTION STUDY AREA, 1952-1957

Year	Postbreeding (September) Population	Prehunt (December) Population	% Pop. Decrease between Sept. & Dec.	% Prehunt Pop. Removed by hunting	% Postbreeding Pop. removed by hunting
1952	116	67	31	18	
1953	88	71	19	24	19
1954	60	65	28	21	16
1955	53	40	24	17	13
1956		9		4	
1957		13		6	

demonstrate the well-known principle of diminishing returns. As density decreased quail became more difficult to find, and hunters lost interest. The year to year decline in hunting pressure parallels the drop in quail density and hunter success as well as in total kill. (Figure 1). The only significant departure from this trend occurred in 1953 when bag per unit effort was substantially lower than 1954 although density was at least as high and perhaps higher in 1953 than in 1954. This discrepancy was probably due to a considerable difference in hunting pressure in the two years: 21 gun hours per 100 acres in 1953 compared to 12 in 1954. The change in hunting pressure in turn was caused by a reduction in size of the adjacent control area in 1954 thereby luring many hunters into this "virgin" territory who would normally have hunted on the study area. Most significant is that with roughly comparable quail densities the removal was only three per cent more in 1953 although hunting pressure was almost twice as great as in 1954. This too reflects the operation of the law of diminishing returns. Affected most by the change in hunting

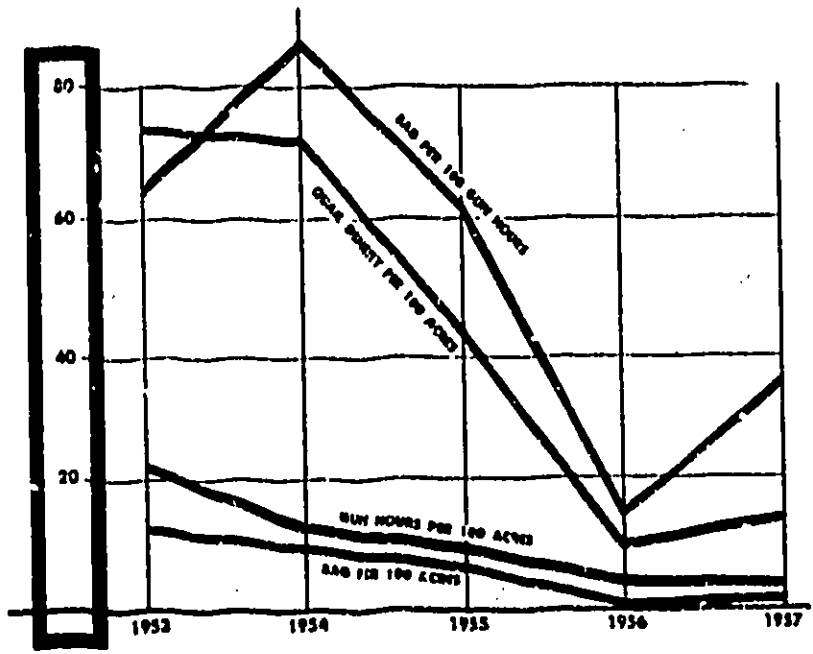

Figure 1. Relation of hunter success, quail density, hunting pressure and kill at Oracle Junction study area.

TABLE 6. COMPARISON OF HUNT AND POPULATION DATA FOR UNITS 1 AND 2 OF THE ORACLE JUNCTION STUDY AREA, 1954-1955

	Unit 1		Unit 2	
	1954	1955	1954	1955
Prehunt density (quail per 100 acres)	97	55	86	39
Hunter success (quail per 100 gun hours)	70	37	88	65
Per cent prehunt population removed by hunting	26	31	10	16
Gun hours per 100 acres	26	31	11	8

pressure was hunter success which went from 63 quail per 100 gun hours in 1953 to 84 in 1954.

A similar relationship is indicated in comparing hunt results of Unit 1 and Unit 2 of the Oracle Junction Study Area (Table 6). A 446-acre section of the hunted area was designated Unit 1 while the balance comprised Unit 2. The division was necessary because only the smaller unit was trapped in September as well as immediately prior to the hunting season to permit a calculation of natural loss during the intervening period.

Removal on the two units was never proportional to hunting pressure (Table 6). In 1954 a removal of 26 per cent on Unit 1 compared to 20 per cent on Unit 2. Hunting pressure that year was more than twice as great on Unit 1 with 26 gun hours per 100 acres compared to 11 on Unit 2. The 31 gun hours per 100 acres in 1955 was roughly four times the eight of Unit 2. The removal, however, of 31 per cent was only twice that of Unit 2. Due to a higher quail density in both years on Unit 1 the relationship is not as clear as it otherwise might be. It was previously shown that removal is proportional to density. It thus seems reasonable to assume that had density been comparable on the two units the effects of the difference in hunting pressure on removal would have been less pronounced—as they were demonstrated to be for the entire study area in 1953 and 1954.

Here too hunting pressure influenced hunter success more than it did total kill. In Unit 1 in 1954, 70 quail were bagged per 100 gun hours, compared to 88 in Unit 2. In 1955, 37 compared to 65 in Unit 2.

At Pinnacle Peak hunters harvested a greater portion of the population than at Oracle Junction. The difference in kill between areas is probably more apparent than real. The per cent removed is based on the per cent of birds banded immediately prior to the hunting season that were taken by hunters. The bulk of the birds banded at Pinnacle Peak were trapped near roads, making them more vulnerable to hunting than those at Oracle Junction where traps were distributed throughout the area and up to one and one-half miles from a road.

While it was not possible to reduce data at Pinnacle Peak to a population density, quail numbers, judging by hunter success, were

undoubtedly higher than on the study area at Oracle Junction. A kill per 100 gun hours of 40 and 46 quail was realized at Pinnacle Peak in 1956 and 1957, compared to 13 and 32, respectively, on the study area at Oracle Junction. In accordance with the results over the years at the latter area showing that removal is proportional to density a higher removal would be expected at Pinnacle Peak. This it was, hunters taking 12 per cent of the population in 1956 and 16 in 1957 compared to four and six per cent, respectively, at Oracle Junction.

3. More quail are lost to natural causes in the two month period immediately preceding the December hunting season than are harvested by hunters during 16-day seasons.

During three years it was possible to get reliable estimates of population loss between September and the beginning of hunting in December. The loss has averaged 23 per cent of the September population for the years 1953 to 1955 (Table 5). (The 1952 estimate is probably high.) If the loss sustained from hunting is figured on the same basis, i.e., as a per cent of the September population instead of from the prehunt population, the average removal by hunters amounted to 16 per cent for this three year period—substantially less than the loss to natural factors during the two months preceding the hunt. The significance of this prehunting season loss is discussed in another section.

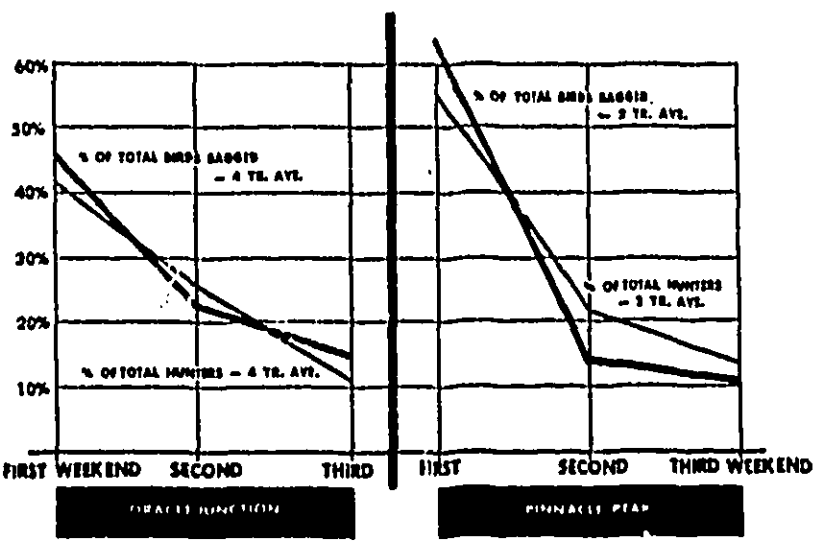

Figure 2. Distribution of hunting pressure and kill through three week-end (16 day) seasons at Oracle Junction and Pinnacle Peak checking stations.

4. Hunting pressure and kill during a hunting season decline as the season progresses regardless of population density or hunter success.

Figure 2 shows graphically the progressive drop in hunting pressure and kill during three week end seasons. At Oracle Junction a four year average shows 43 per cent of total hunters bagging 45 per cent of the quail on the first week end of the season. The last week end accounted for 15 per cent of the quail by 13 per cent of the hunters. At Pinnacle Peak distribution of pressure and kill was even more unbalanced. The two year average showed 53 per cent of the hunters taking 63 per cent of the quail on opening week end, while 13 per cent removed 11 per cent of the quail on the third and final week end.

A decrease in hunting pressure as a hunting season progresses is generally associated with a drop in hunter success. The principle of diminishing returns is generally believed to be at work—as greater effort becomes necessary for each unit of game brought to bag, hunters tend to lose interest. While the operation of this principle was evident in comparing year-to-year data, it fails to account for the decline in hunting pressure as the season progressed. In not one year was there a progressive drop in hunt success from the first to the last week end (Figure 3). In two years at Oracle Junction, 1954 and 1956,

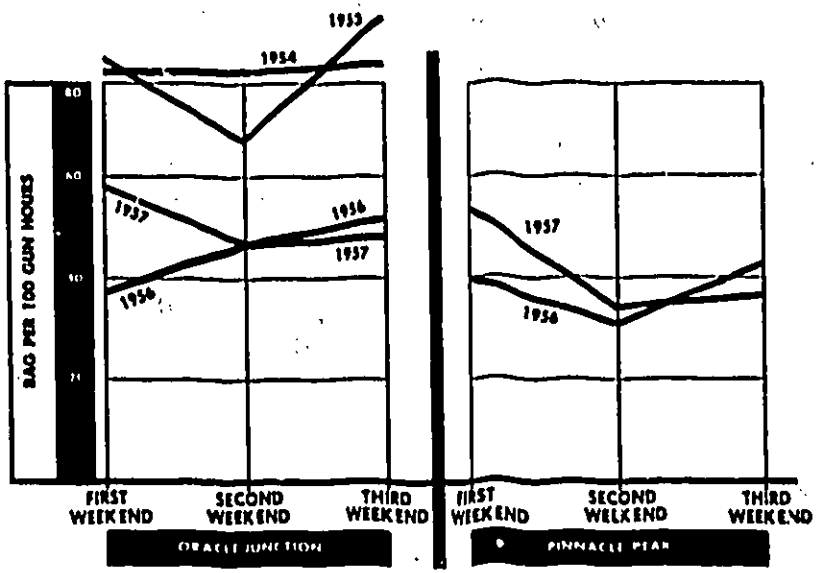

Figure 3. Changes in hunter success (quail bagged per 100 gun hours) through three week-end (16 day) seasons.

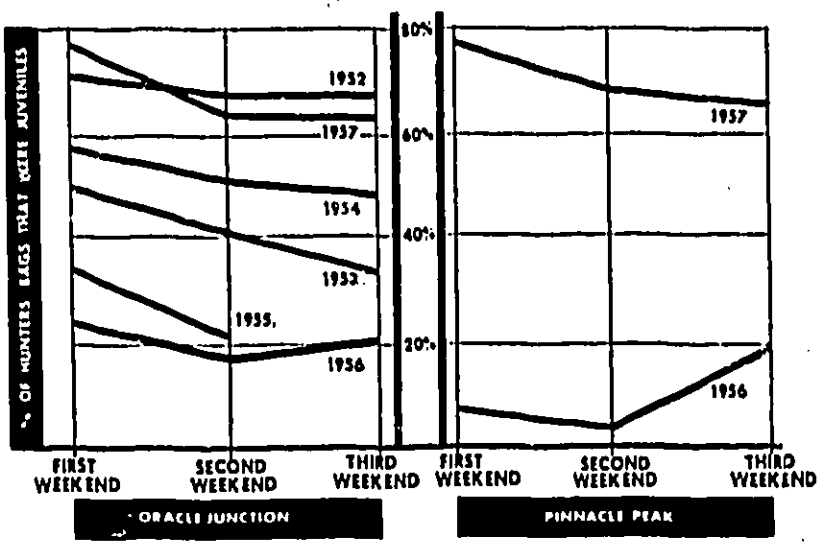

Figure 4. Drop in proportion of juveniles in hunters' bags as season progresses.

success improved steadily from first to third week end; in one, 1953, and one at Pinnacle Peak, 1956, success was higher on the third week end than on the first. Only in 1957 on both areas was third-week end success lower than first, and even here it was somewhat higher on the final week end than on the second. That relative quail density is not a factor here is indicated by the fact that results were the same in years when density was high as when it was low.

5. Hunter success tends to fluctuate with the proportion of young in the population but high density resulting from a good hatch and high survival of young is more of a contributing factor than is the differential vulnerability of young birds.

Gullion (*op. cit.*) concluded that the ratio of young to adult was more important than population density in determining success of Gambels quail hunters in Nevada. While a good relationship between proportion of young in the population and hunter success was found on our study (Table 7) the discrepancies in it raise the question of whether the apparent relationship is not simply due to the population density in most years being largely determined by the proportion of young in the population. That young of the year are more vulnerable to hunting than adults is demonstrated in Figure 4 showing a progres-

TABLE 7. RELATION OF GAMBEL'S QUAIL YOUNG TO ADULT RATIOS AND HUNTER SUCCESS (QUAIL PER 100 GUN HOURS)

Year	Hunter Success	Per Cent Juveniles
	Oracle Junction	
1951	43	44
1952	99	70
1953	85	43
1954	89	53
1955	63	28
1956	44	20
1957	53	74
	Pinnacle Peak	
1956	40	7
1957	46	72

sive drop in the proportion of young in hunters' bags in every year of the study except 1956. The reason for the sharp increase in proportion of young on the third week end of the 1956 season on both areas is not known. There would be little doubt but that of two comparable populations of quail with dissimilar proportions of young, the one with more young birds would produce better hunting. The extent to which a higher proportion of young would offset a lower quail population is a matter of conjecture. However, our data prove conclusively that a high proportion of young does not in itself mean high hunter success. The 74 per cent young found at Oracle Junction in 1957 is the highest for the seven years of the study, yet success is only a trifle higher than that of 1956 when only 20 per cent of the hunted population were juveniles. The 53 quail per 100 gun hours in 1957 when the juveniles made up 74 per cent of the population was considerably lower than the 63 of 1955; the 89 of 1954; or the 85 of 1953 when the proportion of young was only 28, 53 and 43, respectively. Further, success at Pinnacle Peak in 1957, 46 quail per 100 gun hours, was only six per cent more than in 1956, although juveniles made up 72 per cent of the population in 1955 compared to an incredibly low seven per cent in 1956.

DISCUSSION

The fact that hunting has had no influence on Gambel quail populations in Arizona will certainly cause no stir among professional wildlife biologists. Since Errington and Hammerstrom's (1935) early work on bobwhite quail, one small-game study after another has ended on the same note. Most of the investigations along this line have been concerned with bobwhite quail (Baumgartner, 1944; Kozicky and Hendrickson, 1952; Mosby and Overton, 1950; Murray and Frye, 1957; and others). Invariably the conclusion reached has been that a high mortality was characteristic of bobwhite populations regardless of hunting. Pheasants are a somewhat different class since the practice

has been to shoot cocks only. It has been found, however, that cock pheasants are seldom shot down to the level believed desirable or permissible in terms of the number needed for reproduction (Stokes, 1954; Hart, 1954). The list of studies indicating either that hunting was of no significance in maintaining populations and/or an underharvest of small game includes work on virtually all other important species of small game: ruffed grouse (Palmer, 1956), California valley quail (Glading and Sharni, 1944), mourning doves (Newsom, *et al.*, 1957), white-winged doves (Gallizioli, 1956), gray squirrels (Uhlig, 1956), cottontails (Pirnie, 1949 and Atzenhoefer, 1951, and Gambel quail (Gullion, *op. cit.*).

While our findings are thus nothing revolutionary they are but slowly gaining acceptance by a hunting public conditioned by closed or brief hunting seasons to believe that hunting was virtually the only important factor controlling quail populations.

Considering the data on per cent kill, hunter success and amount and distribution of hunting pressure, it appears that under past regulations we have not permanently reduced quail numbers by hunting and that there could well have been considerably more hunting in Arizona without significant effect on quail populations. With the rapid progressive decrease in hunters with three week end seasons it is evident that longer seasons would not contribute significantly more hunting pressure. Further, it is equally apparent from the relation of hunting pressure to total kill that an increase in hunting pressure does not produce a corresponding increase in kill.

The heavy loss to natural factors in the fall months is a well known feature in the ecology of other small game. Knowledge of this factor has prompted game departments to advance their hunting seasons to take advantage of this surplus. An earlier and longer Gambel's quail season in Arizona would be nothing more than sound game management.

SUMMARY

A seven-year study on the effects of hunting on Gambel quail populations revealed that:

1. Quail numbers on an unhunted control area fluctuated about the same as those of a hunted area. When a sharp drop in quail population levels occurred it was equally severe on hunted and unhunted areas.
2. With three week end (16 day) seasons removal by hunting varied from 4 to 24 per cent of the prehunt population (including crippling loss).

3. Removal in any year was directly proportional to quail density; the highest take of 24 per cent occurred in 1953 with quail density at 71 per 100 acres, the low of four per cent came in 1956 when density was but nine per 100 acres.
4. More quail were lost to natural factors between September and the hunting season than were removed by hunting.
5. Hunting pressure and kill decreased rapidly as the season progressed despite the fact that hunter success was generally as high on the last week end as on the first.
6. Although hunter success in any year tends to parallel the ratio of juvenile to adult birds, there is evidence suggesting that quail density is the real determinant of hunter success and that the relation of hunter success to the ratio of young to adult is simply the result of juveniles often being the determining factor in relative quail density.

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Last, but far from least, we gratefully acknowledge the support of former Director John Hall, Game Management Chief Phil Cosper, and the members of the Arizona Game and Fish Commission.

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DISCUSSION

DR. J. J. HICKEY [Wisconsin]: I would like to ask Mr. Gallizioli how he controlled the ingress and egress on the study areas.

MR. GALLIZIOLI: That, of ecurse, is one of *the biggest problems*. We had *no* control over that but what we did was to determine the extent of movement of our population in the area by determining how many of the banded birds killed were taken off the area and then reduced our banded population *by* that *amount* in calculating our population density.